Journal of the Lepidopterists' Society
49(1), 1995, 88–91

MELANISM HAS NOT EVOLVED IN JAPANESE *BISTON BETULARIA* (GEOMETRIDAE)

Additional key words: peppered moth, form "carbonaria."

No example of natural selection in Lepidoptera is more widely recognized than industrial melanism in *Biston betularia* (L.) (Geometridae). In Britain, the common name for the species is the peppered moth because the typical, pale adult is covered with white scales mottled with black splotches. It was the only form known until 1848 when the first melanic variant was discovered near Manchester, England. By the turn of the century about 98% of Manchester *B. betularia* populations were melanic, or "carbonaria" as the jet-black morph came to be known. Similar changes were recorded in the vicinities of other industrial cities throughout Britain. The primary reason for the rise in frequency of the carbonaria form was its enhanced crypsis in polluted woodlands blackened by industrial soot. Against the darker backgrounds, paler morphs were more conspicuous to predators. Because the replacements of paler forms by melanic variants coincided with the industrialization of various regions, the phenomenon was dubbed industrial melanism. For the most comprehensive review of the early history of industrial melanism in *Biston betularia* and other lepidopteran species, see Kettlewell (1973).

Just over a century after the first melanic *B. betularia* was reported, the British government legislated the Clean Air Acts to enforce smokeless zones. Since that time Sir Cyril Clarke has documented a dramatic decline in the frequency of carbonaria from 93% to 23% between 1959 through 1993 on the Wirral Peninsula, just south of Liverpool (Clarke et al. 1985, 1993, 1994). For many years, gray foliose lichens encrusting the boughs and trunks of trees were thought, without any direct evidence, to afford hiding places for the pale form; however, the major reversals in morph frequencies recorded in recent years have occurred in the virtual absence of such lichens (Grant & Howlett 1988), indicating that the role of lichens in the natural history of *B. betularia* has been exaggerated. What seems certain, in any case, is that habitat modifications resulting from industrial practices and related human activities continue to affect the evolution of this species.

B. betularia is a Holarctic species, widely distributed across the higher latitudes or at higher elevations. What were once regarded as separate species have been reclassified as geographic races or subspecies (Rindge 1975, Clarke et al. 1993). The North American subspecies, *Biston betularia cognataria*, is also polymorphic in some populations for a typical form and a melanic variant called "swettaria." American typicals, called pepper-and-salt geometers, are generally darker than British typicals, closer in appearance to intermediate "insularia" forms (Kettlewell 1973). "Swettaria" is indistinguishable from British "carbonaria," and is likewise inherited as a dominant allele at a single locus (West 1977). Although swettaria is rare or uncommon in most *cognataria* populations, it has been recorded at very high frequencies near some industrial regions (Owen 1961, 1962, Sargent 1974, West 1977).

Biston betularia also lives in Japan where its subspecific name is *parva* and its common name is Oo-shimofuri-eda-shaku, meaning frosted, branch-measuring moth. In paleness, Japanese *parva* lies between typical American *cognataria* and British typicals. Published accounts of the whereabouts and "whenabouts" of *parva* are sketchy, however, as it has not attracted much attention in Japan.

Inoue (1982) and R. Sato (pers. comm.) report that the species can be collected in the middle and northeastern part of Honshu during early July to the middle of August, and in Hokkaido from the middle of July until late August. Collectors include it in their reports, but the numbers recorded are conspicuously small (e.g., Kurata 1965 [n = 1]; H. Sato et al. 1985 [n = 3]). In other published lists, it is conspicuously absent [n = 0] (e.g., Kurata 1969, H. Sato & Fukuda 1985, H. Sato et al. 1986). By contrast, the Wirral census of British *B. betularia* has averaged 500 specimens per year over the past 35 years in one location (Clarke et al. 1994). Clearly, Japanese *Biston betularia* has not been the focus of similar scrutiny. Here we report our attempts to survey populations of *B. betularia*

TABLE 1. The numbers of *Biston betularia* trapped at various locations in Japan.

Date[1]	Location	Latitude	Altitude (m)	No. of moths	Method[2]	Collector[3]
1988						
6/4–13	Setagaya Tokyo	35°37′	40	0	a	
6/14–29	Takao, Tokyo	35°39′	300	0	a	
7/3–7	Aizu-arakai, Fukushima	37°09′	400	0	a	
7/13–15	Ohizumi, Yamanashi	35°53′	1000	0	a	
Mid-July	Yuzawa, Niigata	36°36′	1000	16	a, b	Rikio Sato
7/22–8/5	Mikasa, Hokkaido	43°24′	200	0	a	
8/5	Sapporo, Hokkaido	43°13′	15	1	c	Masahito Kimura
8/6	Tomuraushi, Hokkaido	43°20′	600	0	a	
8/8–11	Mikasa, Hokkaido	43°24′	200	0	a	
8/6–16	Minami-aiki, Nagano	36°02′	1300	67	b	Masamitu Wada
8/15–17	Takao, Tokyo	35°39′	300	0	a	
9/1–7	Shiga, Nagano	36°42′	1600	1	a	
1992						
7/4	Kawakami, Nagano	35°56′	1400	2	a, b	
7/20–24	Sugadaira, Nagano	36°32′	1600	107	a, b	
7/28	Mt. Odaido, Iwate	39°44′	1000	3	b, c	Nobuo Doi
8/1	Mt. Hiromori, Akita	40°22′	300	5	a, b	Masayuki Tanaka
Early Aug.	Namiai, Nagano	35°34′	1000	2	c	Michio Ihara
1993						
7/15–17	Sugadaira, Nagano	36°32′	1600	103	a, b	

[1] One trapping night spans two dates; dates listed indicate the evening traps were started, not the following morning.
[2] a = MV Robinson trap, b = black light & sheet method, c = fluorescent lamp.
[3] Collections by other than authors are listed.

parva from rural and urban/industrial vicinities to determine whether or not industrial melanism has also occurred in Japan.

We used two kinds of light traps to sample moth populations: a) Robinson funnel traps (Robinson 1952) with mercury vapor lamps (100 or 160 watt) and b) fluorescent black lights (20 watt) used to illuminate sheets of stretched white cloth or plastic 2-mm mesh.

Table 1 lists all of the trapping sites and the total numbers of *B. betularia* taken during the time intervals shown. The species was absent in our moth catches taken in mixed deciduous stands in the Tokyo area, but it was present in rural habitats geographically distant from industrial centers. The largest samples were collected at three localities: 1) Yuzawa, Niigata, 2) Minami-aiki, Nagano, 3) Sugadaira, Nagano. Straight lines between these collection points are only 50 to 90 km long, but direct passage is thwarted by complicated ranges of mountains higher than 2000 m. The sites in Yuzawa and Minami-aiki are surrounded by forests abundant in *Larix kaempferi* (Lambert) (Pinaceae) and some *Betula platyphylla* Sukatchev (Betulaceae). In Sugadaira, collections were made in the center of a cattle field where *Betula ermanii* Chamisso and *B. platyphylla* birch trees are maintained. *Larix kaempferi* and *B. ermanii*, both of which are listed as host plants of *Biston betularia parva* by Inoue (1982), are likely major food sources for the populations we sampled.

Sample size differences at the various locations likely result from combinations of factors, including weather conditions and, especially, seasonal timing. *Biston betularia* flies at different times during the summer in different parts of its distribution. On the Wirral, for example, Sir Cyril Clarke routinely operates his trap each year from 1 June through 31 July (Clarke et al. 1994), but the best time to collect this species lasts only about two weeks beginning around the middle of June. A few are flying as early as late May, but by August the breeding season for *B. betularia* is over on the Wirral, although there is

an abundance of other moth species still flying. August, on the other hand, is a good month for trapping *B. betularia cognataria* in the mountains of Virginia (West 1977, Grant & Howlett 1988) where the species is bivoltine. Yet, *cognataria* have never been reported just a few hundred miles away in eastern Virginia. Thus, over short geographic, altitudinal, and temporal distances, the species may be present or absent in collections. Once a specimen is caught at a location, we can be certain that it occurs there, but its absence proves nothing unless traps are run at the same location throughout an entire season, and preferably over several years.

To our knowledge (through previous experience from trapping in England, the Green and White Mountains of Vermont and New Hampshire, New York's Adirondacks, Michigan's Upper Peninsula, as well as the Appalachian Mountains and Coastal Plain of Virginia), the species does not thrive where summers are long and hot. At the same latitudes, however, it may be common at higher elevations where cooler temperatures prevail. *Biston betularia* is reportedly capable of feeding on 30 widely different genera of host plants (Tietz 1972), many of which are common where this moth species apparently is not; therefore we would not suggest that its distribution is solely restricted to the availablility of potential host plants.

Different wave lengths of light are variously effective in trapping different moth species (Robinson 1952). We considered the possibility that the paucity of *B. betularia* in our traps during the 1988 season might have resulted from the wrong wave length emitted by the Toshiba 100 watt MV bulbs used by us for the first time that year, even though the traps caught hundreds to thousands of moths of numerous other species each night. The following year, however, the same bulbs were used successfully to trap *B. betularia* elsewhere, thus eliminating wave length as the explanation for the absence of this species in the traps at certain locations.

In all, we examined 307 specimens of this species during the course of our study. No melanics were found at any location. We cannot conclude that melanic variants are entirely absent in Japanese *B. betularia*, but it seems reasonable to conclude that such forms are not common. This conclusion is reinforced by H. Inoue (pers. comm.) who indicated that to his knowledge no one has ever reported collecting a melanic variant of *B. betularia* in Japan. As Owen (1962) has observed, rare forms often are over-represented in museum collections simply because they are rare. All things taken together strongly argue that color polymorphism does not exist in *B. betularia* populations anywhere in Japan. This does not preclude that rare variants arise by recurrent mutation, but considerably larger sample sizes are necessary to assess mutation rates.

Based on this study and from the collective experience of other workers in Japan, it appears that this species and Japanese industry are allopatric, i.e., heavy industry is mainly concentrated along the coast, and *B. betularia* lives in the central mountains and farther north. In our judgment, Japanese industry has not blackened the surrounding countryside as did British industry during its prime. Hence, even if *B. betularia* populations do occur near Japanese industrial centers, it is unlikely that a carbonaria-like form arising by mutation would enjoy the same advantage as it once did in Britain.

Rikio Sato and Masamitsu Wada made collections of *B. betularia* and kindly allowed us to use their data. Osamu Kitagawa and Yoshiaki Fuyama provided invaluable support while B.G. was Visiting Professor at Tokyo Metropolitan University during sabbatical leave. Katsura Beppu, Michio Ihara, Masahito Kimura, Kunihei Kishi, Ryuichiro Machida, Atsumi Moriyama, Mikio Ono, Masaaki Tanaka, and Nobuo Tsuchii helped us in the field and laboratory. Hiroshi Hori and Hiroshi Inoue offered useful suggestions for field collections. This research was partly supported by a Grant-in-aid for Encouragement of Young Scientists (04858077) from the Ministry of Education, Science and Culture, Japan, and a Faculty Research Assignment and Summer Grant from the College of William & Mary. Suggestions from Frederick Rindge, Charles Covell and John Brown helped us improve our report.

LITERATURE CITED

CLARKE, C. A., G. S. MANI & G. WYNNE. 1985. Evolution in reverse: clean air and the peppered moth. Biol. J. Linn. Soc. 26:189–199.

CLARKE, C. A., F. M. M. CLARKE & B. GRANT. 1993. *Biston betularia* (Geometridae),

the peppered moth, in Wirral, England: an experiment in assembling. J. Lepid. Soc. 47:17–21.

CLARKE, C. A., B. GRANT, F. M. M. CLARKE & T. ASAMI. 1994. A long term assessment of *Biston betularia* (L.) in one UK locality (Caldy Common, West Kirby, Wirral), 1959–1993, and glimpses elsewhere. The Linnean (in press).

GRANT, B. & R. J. HOWLETT. 1988. Background selection by the peppered moth (*Biston betularia* Linn.): Individual differences. Biol. J. Linn. Soc. 33:217–232.

INOUE, H. 1982. The Geometridae, pp. 425–573. *In* Moths of Japan, vol. 1. Kodansha. Tokyo. (In Japanese.)

KETTLEWELL, H. B. D. 1973. The Evolution of Melanism. Clarendon Press, Oxford, England. 423 pp.

KURATA, M. 1965. Records of moths from the Shigakogen. Bull. Inst. Biol., Shiga Heights, Shinshu Univ. 4:19–34. (In Japanese with English abstract.)

———. 1969. Records of moths from the Shiga Heights II. Bull. Inst. Natur. Educ., Shiga Heights, Shinshu Univ. 8:17–26. (In Japanese with English abstract.)

OWEN, D. F. 1961. Industrial melanism in North American moths. Am. Nat. 95:227–233.

———. 1962. The evolution of melanism in six species of North American geometrid moths. Ann. Entomol. Soc. Am. 55:695–703.

ROBINSON, H. S. 1952. On the behaviour of night-flying insects in the neighbourhood of a bright source of light. Proc. Roy. Entomol. Soc. London A 27:12–21.

RINDGE, F. H. 1975. A revision of the New World Bistonini (Lepidoptera: Geometridae). Bull. Am. Mus. Nat. Hist. 156:69–155.

SARGENT, T. D. 1974. Melanism in moths of central Massachusetts (Noctuidae, Geometridae). J. Lepid. Soc. 28:145–152.

SATO, H. & H. FUKUDA. 1985. Faunal makeup of macrolepidopterous moths in Nopporo Forest Park, Hokkaido, northern Japan, with some related notes. Environ. Sci., Hokkaido 8:93–120.

SATO, H., K. OKAZAKI & H. FUKUDA. 1985. Macrolepidopterous moth fauna on a volcano Mt. Usu six years after the 1977–78 eruptions. Environ. Sci., Hokkaido 8:121–139.

SATO, H., S. HIGASHI & H. FUKUDA. 1986. Nocturnal flight activity of moths. Environ. Sci., Hokkaido 9:59–68.

TIETZ, H. M. 1972. Index to the described life histories, early stages and hosts of the macrolepidoptera of the continental United States and Canada. A.C. Allyn, Sarasota, Florida. 1041 pp.

WEST, D. A. 1977. Melanism in *Biston* (Lepidoptera: Geometridae) in the rural Central Appalachians. Heredity 39:75–81.

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Received for publication 13 February 1994; revised and accepted 23 June 1994.

Journal of the Lepidopterists' Society
49(1), 1995, 91–94

FIRST RECORDS OF *PARACHORANTHUS MAGDALIA* (HESPERIIDAE) FROM THE BAHAMAS, AND EXTENSION OF THE BAHAMIAN RANGE OF *BATTUS DEVILLIERS* (PAPILIONIDAE)

Additional key words: West Indies, Cuba, dispersal, colonization, biogeography.

The addition of butterfly species to faunal lists in the Bahamas and elsewhere in the West Indies may reflect discovery of long-established but overlooked populations, chance interception of newly arrived vagrants, or discovery of new colonies they have established. Species that are not on the wing throughout the year may readily be missed on islands